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Wild Predators, Livestock, and Free Ranging Dogs: Patterns of Livestock Mortality and Attitudes of People Toward Predators in an Urbanizing Trans-Himalayan Landscape

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Livestock depredation by large carnivores is a significant source of conflicts over predators and an important conservation and economic concern. Preventing livestock loss to wild predators is a substantial focus of human-carnivore conflict mitigation programs. A key assumption of the preventive strategy is reduction in the livestock losses leading to a positive shift in the attitudes toward predators. Therefore, it is important to quantify the true extent of livestock mortality caused by wild predators and its influence on attitudes of the affected communities. We examined seasonal and spatial patterns of livestock mortality and factors influencing people's attitudes toward wild predators i.e., snow leopards (*Panthera uncia*) and wolves (*Canis lupus* chanco) and free-ranging dogs (*Canis lupus* familiaris) in a Trans-Himalayan urbanizing landscape in India. We used systematic sampling to select the survey households and implemented a semi-structured questionnaire to respondents. The sampled villages ($n = 16$) represent a mosaic of urban and agricultural ecosystems within a radius of 40 km of Leh town. In 2016–2017, 93% of the sampled households lost livestock to predators, accounting for 0.93 animals per household per year. However, of the total events of livestock mortality, 33% were because of weather/natural events, 24% by snow leopards, 20% because of disease, 15% because of free-ranging dogs and 9% because of wolves. The annual economic loss per household because of livestock mortality was USD 371, a substantial loss given the average per capita income of USD 270 in the region. Of the total loss, weather/natural events caused highest loss of USD 131 (35%), followed by snow leopards USD 91 (25%), disease USD 87 (24%), free ranging dogs USD 48 (13%), and wolves USD 14 (4%). Despite losing a considerable proportion of livestock (33 %) to wild predators, respondents showed a positive attitude toward them but exhibited neutral attitudes toward free-ranging dogs. Gender emerged as the most important determinant of attitudes toward wild predators, with men showing higher positive attitude score toward wild predators than women. Our findings highlight the context specific variation in human-wildlife interactions and emphasize that generalizations must be avoided in the absence of site specific evidence.

Keywords: ***Canis lupus*, human-wildlife relationships, human-wildlife conflict (HWC), livestock depredation, multiple use landscapes, *Panthera uncia*, pastoralism, urban wildlife**

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INTRODUCTION

Livestock depredation is a significant source of conflict over predators (Hussain, 2003; Ikeda, 2004; Bagchi and Mishra, 2006). The conflicts arise between different human beliefs concerning whether livestock predation by predators is acceptable and how predators should be managed in shared landscapes. The negative human-wildlife interactions manifest in the form of economic losses, lost opportunity costs, psychological fears, and direct threats to safety for humans and in the form of reduced tolerance, lethal control, and retaliatory killings for predators. As the human population continues to grow, finding effective ways to conserve predators has become increasingly challenging (Woodroffe, 2000). A global analysis of the status of large predators revealed that out of the 31 species belonging to five families, 61% are classified as threatened (critically endangered, endangered or vulnerable) by IUCN (Ripple et al., 2014). Maintaining viable populations of predators is a global conservation challenge since their extensive needs of space and food often overlap and conflict with human interests.

Globally, ∼55% of the total cases of snow leopard poaching are attributed to retaliatory killing of snow leopards and estimates suggest that livestock depredation incidents in about 48% of the cases lead to a poaching event (Nowell et al., 2016). The tolerance toward Tibetan wolves is even lower (Suryawanshi et al., 2014; Kusi et al., 2019) and traditional pit traps to capture wolves are common in many parts of the Indian Trans-Himalaya. The potential for conflict and reduced social tolerance for wild predators is further aggravated at sites where free-ranging dogs kill more livestock than native wild predators (Home et al., 2017). Persecution of predators by humans over real or perceived threats is one of the primary reasons for the global decline in carnivore populations and their endangerment (van Eeden et al., 2018). The critical question therefore is whether it is possible to reconcile livestock production with carnivore conservation in shared multiple-use landscapes.

In the Trans-Himalayan region, the pastoral and agro-pastoral communities share space with wild predators such as snow leopards (*Panthera Uncia*) and Tibetan wolves (*Canis lupus*). Pastoralism and agro-pastoralism are the predominant land use types in the region and might be several millennia old (Hāṇḍā, 1994) and presumably involved low-intensity grazing (Blench and Sommer, 1999). Of the ∼186,000 km^2 of the Trans-Himalayan region, only about 8% is formally protected (Rodgers et al., 2002) and wildlife outside of the protected areas generally occur at suppressed population densities (Mishra et al., 2010). Conservationists contest the compatibility of livestock production and wildlife conservation in the region (Saberwal, 1996; Mishra and Rawat, 1998). However, recent work shows that livestock grazing and snow leopard conservation are compatible up to certain thresholds of livestock stocking densities (Sharma et al., 2015). But, livestock depredation by predators, primarily snow leopards and Tibetan wolves in the Trans-Himalaya, results in severe economic losses to people (Bagchi and Mishra, 2006; Namgail et al., 2007a; Jamtsho and Katel, 2019) and often results in the retaliatory killing of the species by the aggrieved herders.

Considering livestock depredation as the key driver of the negative attitude of people toward predators is a common assumption in most studies on human-snow leopard interactions. However, local communities can relate to predators in complex, multifaceted and ambivalent ways (Goldman et al., 2010). Conservation strategies in shared landscapes almost invariably focus on livestock loss caused by wild predators and potential mitigation measures. Do wild predators cause significant livestock and economic loss, and does this result in negative attitudes toward predators across shared landscapes? Should conservation programs focus on reducing livestock mortality by wild carnivores and implicitly assume that it would lead to desired conservation outcomes such as social acceptance of predators and reduced economic losses, or should it vary depending on social and environmental contexts of a site? To address these questions, we examined (i) the seasonal and spatial patterns of livestock mortality and the causative agents of livestock loss and (ii) the factors influencing the attitudes of local communities toward predators in our study area. We interviewed local people in a multiple use peri-urban landscape in Ladakh to understand their attitudes toward wild predators and free ranging dogs and to record the extent and causative agents of livestock mortality.

MATERIALS AND METHODS

Study Area

Ladakh is a remote north-western Trans-Himalayan region in India, between 75°50′E to 80°E and 32°30′N to 37°N. Geographically, Ladakh represents the westernmost extension of the vast Tibetan Plateau, covering an altitude range between 2,700 and 7,650 m (Namgail et al., 2007b). Leh district where our study was conducted has one uninhabited and 112 inhabited villages with a population of 13,3487 people as per the 2011 census (http://censusindia.gov.in/). Topographically, the entire district is mountainous with three parallel ranges of the Himalaya: Zanskar, Ladakh, and the Karakoram.

The study area represents a mosaic of urban and agricultural ecosystems within a radius of 40 km of Leh town, the major urban center in Leh district in the union territory of Ladakh, India. The residents of the sampled villages relied on Leh town for jobs, healthcare, and other administrative services. Unlike remote villages of the district, the sampled villages benefited from diversification of livelihood opportunities provided mainly by government jobs and tourism operations due to proximity to Leh town.

The people are primarily agro-pastoralists with subsistence agriculture and livestock rearing being the primary occupations. Livestock rearing remains an essential activity for cultural and economic reasons even for people who have alternative livelihood options. Livestock grazes in pastures throughout the year except for peak winters when they are stall-fed with a mixture of agricultural residue (mainly stalks of local pea, wheat, and barley) and grass collected from the pastures (Bharti et al., 2017).

Livestock species includes cow (*Bos indicus*), demo (female yak), donkey (*E. asinus*), dzo (a hybrid of cow and yak), dzomo (female dzo), goat (*Capra hircus*), horse (*Equus caballus*),

sheep (*Ovis aries*), and yak (*Bos grunniens*). Mammalian wildlife includes bharal (*Pseudois nayaur*), ibex (*Capra sibirica*), snow leopard (*Panthera uncia*), wolf (*Canis lupus*), wild dog (*Cuon alpinus*), wooly hare (*Lepus oiostolus*) urial (*Ovis orientalis vignei*), and kiang (*Equus kiang*).

The persecution of wild predators such as snow leopards and wolves because of livestock depredations has been historically common across their distribution range (Jackson and Wangchuk, 2001; Bagchi and Mishra, 2006).

Sampling Design

We conducted semi structured questionnaire surveys (Newing et al., 2010) between April and May 2017 to collect data on extent and causes of livestock mortality and attitudes of local people toward snow leopards, wolves, and free ranging dogs. The sampled villages ($n = 16$) represent a mosaic of urban and agricultural ecosystems within a radius of 40 km of Leh town.

We used systematic sampling to select the households to be surveyed by selecting the first household by picking a number between 1 and 10 using a random number generator and using a fixed sampling interval of 2 to select subsequent houses. We used systematic sampling as we could not construct a sampling frame due to lack of recent census data in the region. Respondents from within a household with primary knowledge of predation events and livestock management practices were interviewed, with the help of a local field assistant. We interviewed one adult from each household with his/her consent, by describing the purpose of the study, assuring confidentiality, and clarifying that a participant could choose to withdraw consent for participation at any point of the interview. None of the respondents refused consent or withdrew during an interview. Ethical approval for the study was obtained from WWF-India. The sampled villages were within a radius of 40 km from Leh town and primarily comprised an agro-pastoral community (**Figure 1**).

Questionnaire Surveys

We used semi-structured interviews as they are flexible, can help contextualize perspectives and provide better insights for quantitative analysis (Rust et al., 2017). Open-ended questions helped us gain a richer understanding of the traditional livestock management system and the ongoing changes in the region. We piloted the questionnaire in four villages in the study area to assess for clarity, potential biases, and duration of interviews and made necessary changes before the field survey. The semi-structured questionnaire also enabled informal discussions to understand the history of livestock production in the study area, changes in the livestock herding practices and its linkages with the ongoing socio-economic changes in the landscape.

We interviewed respondents in Hindi language, but for a few respondents who were not comfortable using Hindi, the local field assistant translated questions and responses into the local Ladakhi language.

Patterns and Causes of Livestock Mortality

We recorded self-reported livestock numbers and livestock loss attributed to wild predators, free-ranging dogs, disease, and extreme weather/natural events to understand patterns of livestock mortality and its underlying causes. The data on livestock depredation and mortality is for period between January 2016 and March 2017, immediately preceding the interviews. For livestock predation events, we recorded "recalled" information on location of kill (e.g., pasture, corral, village), the season (e.g., winter, spring, summer, autumn), time (e.g., morning, afternoon, evening, night), age of livestock (e.g., adult, sub-adult, young), sex of livestock and presence of herder (e.g., whether present/absent). We had to rely on "recalled losses" and related parameters since people in the study area do not maintain written records of livestock losses.

Livestock price can vary over years and can also fluctuate within a year, making it difficult to measure it precisely. To determine the economic losses incurred due to livestock loss, we calculated the market value of individual livestock based on age and sex by averaging the procurement price stated by local butchers and the selling price offered by herders during our study. We quantified the losses incurred because of wild predators, free ranging dogs, and disease for the year 2016–2017 in Indian rupees (INR) and converted to USD (I USD = 65 INR ∼2017) for ease of comparison with other studies.

The government provides compensation for livestock killed by snow leopards and wolves, but respondents in our study area explained that they do not apply for compensation, as the amount is a meager 10% of the actual livestock value and applying and getting compensation tedious and time-consuming. Since there was no perverse incentive to report higher depredation for any of the predators involved, we did not expect this to influence the accuracy of predator identity. We relied on the respondents to self-report the predator identity, though misidentification could have occurred occasionally. It is easy to pinpoint the predator accurately when a depredation event occurs inside the corrals or agricultural fields near the village, but predator identity could be difficult to establish accurately for livestock depredation events occurring in the pastures away from the villages. For instance, the livestock kills in pastures could be mis-attributed to snow leopards or wolves when it might have been killed by free ranging dogs.

Quantifying Attitudes Toward Predators

We quantified the attitudes of respondents toward wild predators and free-ranging dogs based on eight closed questions. The questions offered limited options to choose from and sum of scores could range between $+10$ and -10 with $+10$ representing the most positive attitude and -10 representing the most negative attitude (**Table 1**; Suryawanshi et al., 2014).

Attitudes scores of < -1 were considered negative, $> +1$ positive and scores from -1 to $+1$ were considered neutral. We did not use a Likert-type scale as it has been reported to be difficult to understand in Asian cultures (Lee et al., 2002) and in a similar site in the Trans-Himalaya, respondents found it difficult to differentiate between responses such as "agree" and "strongly agree" (Suryawanshi et al., 2014).

The 8 questions covered a range of themes to reveal peoples' attitude toward predators that included (1) what immediately came to the mind of the respondents when they thought about a carnivore: to understand how a respondent related to predators

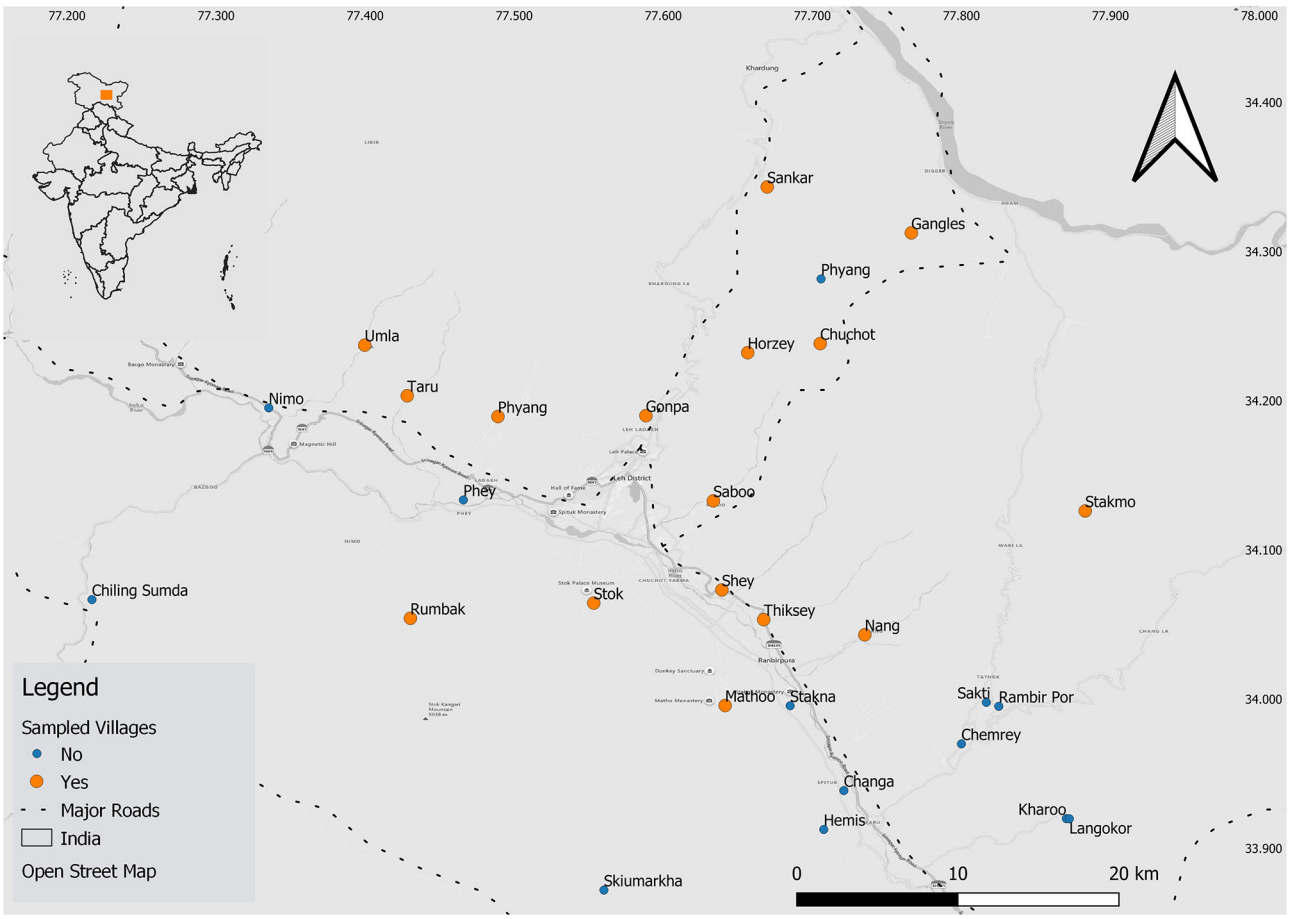

FIGURE 1 | Map of the study area showing the location of villages and villages surveyed in the Ladakh region. Map inset shows the location of the study area in the union territory of Ladakh, India.

in their environment specifying no particular context (Oli, 1994; Bagchi and Mishra, 2006); (2) whether respondents appreciated seeing predators in their environment: to examine if respondents ascribed any aesthetic value to predators (Goldman et al., 2010); (3) whether respondents thought presence of predators was a sign of a healthy environment: to understand whether respondents considered predators to play a role in maintaining healthy natural environments. Such views can be influenced by religious beliefs about the importance of and interconnectedness of living beings (Bhatia et al., 2016) or traditional ecological knowledge that pastoral communities have developed over several millennia of living with predators (Rong, 2008); (4) whether they would support conservation of predators such as snow leopards and wolves: to understand if respondents would support conservation of predators despite economic and opportunity costs of living with predators (Hanson et al., 2019); (5) whether we should teach children about predators in their School: to assess whether respondents considered predators to be a part of their life and culture and considered it important to impart knowledge about predators to their children (Suryawanshi et al., 2014); (6) whether respondents felt that investing in conservation of predators would be beneficial for their local environment (Ceauşu et al., 2018); (7) where the predators should be protected: to understand whether respondents were willing to share space with predators (Chapron et al., 2014); and (8) how a respondent would react if a carnivore killed their livestock: to understand whether losing livestock to predators would generate an extreme response such as retaliatory killing even if people are otherwise willing to share space with predators (Marchini and Macdonald, 2012).

We used Cronbach's alpha reliability coefficients to examine the internal consistency of scales and to improve the coherence of the attitude scale by discarding questions to maximize the alpha value (Vaske, 2008). This resulted in dropping the eighth question that sought response for a hypothetical event of livestock loss to a predator. To further assess the reliability of the attitude scale, we conducted an exploratory factor analysis which showed that the data from the remaining seven questions used to develop the attitude construct was unidimensional. We therefore assume that the underlying factor being addressed by our survey questionnaire is "attitude."

For each respondent, the recorded explanatory covariates included age, gender (as male or female), family size, religion,

TABLE 1 | Questions along with their corresponding scores used to quantitatively assess the attitudes of local people toward snow leopards, wolves, and free ranging dogs in Leh, 2017.

Questions	Possible reply	Corresponding score	Response to snow leopard (%)	Response to wolves (%)	Response to free ranging dogs (%)
1. What comes to your mind when you think of snow leopards/wolves/free ranging dogs	Like	+1	69.3	64.0	21.1
	Dislike	−1	19.3	26.4	73.7
	Indifferent	0	11.4	9.6	5.2
2. I would like to see snow leopards/wolves/free ranging dogs' in the pastures and mountains around my village	Yes	+1	85.1	81.6	28.9
	No	−1	12.3	14.9	66.7
	Don't know	0	2.6	3.5	4.4
3. The presence of snow leopards/wolves/free ranging dogs is a sign of a healthy environment	Yes	+1	86	81.6	26.3
	No	−1	7	8.8	11.4
	Don't know	0	7	9.6	62.3
4. If snow leopards/wolves/free ranging dogs were to be protected in Ladakh, would you support it?	Yes	+1	93.9	92.1	60.5
	No	−1	3.5	3.5	32.5
	Don't know	0	2.6	4.4	7.0
5. Should children be taught about these animals in their school?	Yes	+1	97.4	94.8	77.2
	No	−1	2.6	2.6	16.7
	Don't know	0	0.0	2.6	6.1
6. Do you think the conservation of these animals is beneficial for the environment of Ladakh?	Yes	+1	86.8	84.2	39.5
	No	−1	8.8	8.8	51.7
	Don't know	0	4.4	7.0	8.8
7. Where should the carnivores be protected?	Everywhere	+2	43.0	40.4	28.1
	Only National parks	+1	50.0	50.0	21.1
	Don't know	0	1.8	4.4	11.4
	Zoo	−1	3.5	3.5	19.3
	Nowhere	−2	1.7	1.7	20.1
8. If a carnivore kills your livestock, how would you respond?	Let it feed, the poor animal must have been hungry	+2	36.8	34.2	18.4
	I will do nothing, i can bear to lose 1–2 livestock once in a while	+1	3.5	3.5	1.8
	I don't know what to do	0	2.6	3.5	4.4
	I will chase it away and use the remains of the kill	−1	57.1	58.8	71.9
	I will kill the animal if law permits	−2	0.0	0.0	3.5

level of formal education, primary occupation, sources of income, livestock holdings, cases of livestock depredation, and overall livestock mortality.

Data Analysis

We used descriptive statistics to examine and summarize data on livestock mortality and depredation patterns, including seasonal and spatial variation in livestock mortality. We used Students paired *t*-test to examine the difference between mean attitudes scores toward snow leopards and wolves (Quinn and Keough, 2002).

We built a candidate set of eleven models wherein each model in the candidate set included individual-level explanatory variables and village as a random effect since respondents from the same village can be considered as repeated measures for attitudes from a village (**Appendix I**). We used a linear mixed-effects model to understand the key factors influencing people's attitudes toward snow leopards, wolves, and free-ranging dogs. As fixed effects, we entered gender, religion as factor variables and age, education, the number of income sources, the number of livestock killed, and the number of livestock owned as continuous variables. As random effects, we had intercepts for villages. The response variable was the cumulative attitude score of each respondent based on seven questions which ranged between −8 and +8. The same set of candidate models were used to examine the correlates of attitudes toward snow leopards, wolves, and free-ranging dogs. Akaike's Information Criterion values corrected for small sample sizes (AIC_c) were used to select the best-approximating model from the set of candidate models, including the global model containing all explanatory variables (Burnham et al., 2011). We used model averaging to estimate the coefficients

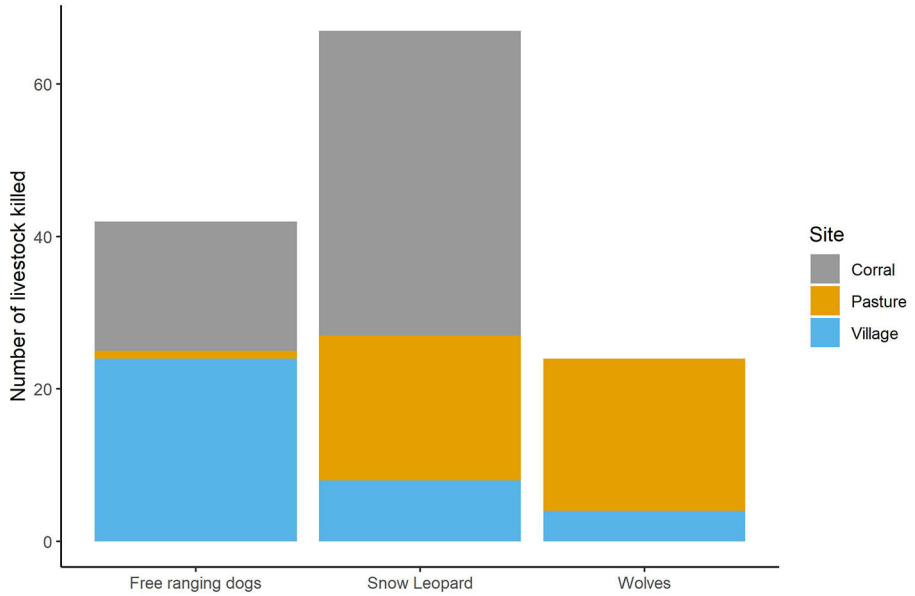

FIGURE 2 | Livestock depredation by snow leopards, wolves and free ranging dogs across livestock stocking pens (Corrals), pastures, and fields close to villages.

for models withing 2 Δ AIC_c of the best model (Anderson and Burnham, 2002). We conducted all the data analysis using R version 3.4.3 (Team, 2017) using function lmer in package lme4 (Bates et al., 2015) and function reliability in the package psych (Revelle, 2019).

RESULTS

Seasonal and Spatial Patterns of Livestock Mortality and Depredation

We surveyed 114 households in 16 villages, that included 41 men and 73 women with 91 belonging to the Buddhist faith and 23 belonging to Muslim faith.

Respondents reported 282 cases of livestock mortality in 16 villages from January 2016 to March 2017, out of which the weather/natural events caused highest livestock mortality (34.04%), followed by snow leopards (23.76%), disease (18.79%), free-ranging dogs (14.89%), and wolves (8.51%).

Livestock depredation by the predators (snow leopards, wolves, and dogs) was highest in winter (53.70%) when livestock are mostly stall fed but also left to graze in fallow agricultural fields in the proximity of villages, followed by summer (16.57%) and spring (14.81%) when people are pre-occupied with agricultural work followed by autumn (14.81%). Overall, the livestock loss to predators was highest in the afternoon (58.70%, 12–5 P.M.) followed by night (21.74%, 8 P.M.−5 A.M.), evening (10.87%, 5–8 P.M.) and least in the morning (8.70%, 5 A.M.−12 P.M.). The highest depredation of livestock in the afternoon coincided with the period when respondents were busy in agricultural activities, and left livestock to graze unattended.

Snow leopards killed more livestock inside in traditional corrals (59.70%) than in pastures (28.36%) and the immediate vicinity of the village (11.94%) (**Figure 2**). All daytime predation events by snow leopards occurred in the pastures away from the villages. Wolves killed livestock mostly in the pastures (83.33%), occasionally in vicinity of the village (16.67%) and did not kill any livestock inside corrals. Free-ranging dogs, killed most livestock in the immediate vicinity of the village (57.14%), followed by corrals (40.48%) and occasionally in the pastures (2.38%).

Economic Losses Because of Livestock Mortality and Depredation

The surveyed villages in the year 2016–2017 incurred a total monetary loss of US $52911 (INR 34,39,215) because of livestock mortality (**Table 2**). The average livestock holding was 21.32 (SD = 59.61) and the average livestock loss was 2.52 (SD = 5.78). Extreme and unpredictable weather-related events caused the highest economic loss (35.26%) followed by snow leopards (24.58%), disease (23.55%), free-ranging dogs (12.95%), and wolves (3.66%).

Amongst predators, we could attribute the highest economic losses to snow leopard (59.67%) followed by free-ranging dogs (31.43%) and wolves (8.89%). Snow leopards caused higher economic losses as they not only killed more livestock but a higher proportion of high-value livestock such as the cow and dzo (a hybrid of cow and yak) (**Table 2**). The average annual loss per household because of livestock mortality was USD 371(INR 24,115), out of which the average annual loss per household because of livestock predation by predators was USD 153 (INR 9945, 41.19% of total losses); USD 91(INR 5915) for snow leopards, USD 48 (INR 3120) for free-ranging dogs and USD 14 (INR 910) for wolves.

TABLE 2 | Economic losses because of livestock mortality and depredation due to wild carnivores, free ranging dogs, disease and weather from January 2016 to March 2017.

Reason of loss	Sheep	Goat	Dzo	Cow	Yak	Horse	Donkey	Total	Economic loss (USD)	% Economic loss
Snow leopard	19	30	4	10	0	2	2	**67**	13004.60	25
Wolf	0	20	0	1	0	0	3	**24**	1938.47	4
Free ranging dogs	29	0	0	7	0	0	6	**42**	6850.77	13
Disease	15	21	2	17	0	0	0	**55**	12461.54	24
Weather	18	52	5	18	1	0	0	**94**	18655.39	35
Total	**81**	**123**	**11**	**53**	**1**	**2**	**11**	282	**52910.77**	
Market value per unit (USD)	118.46	69.23	692.31	461.54	1153.85	615.38	30.77			

The estimated market price of each livestock type is provided for comparison.

Attitudes Toward Wild Predators and Free-Ranging Dogs

Cronbach's alpha reliability for the attitudes scale was 0.68 with all the questions included and improved to 0.75 after removing the hypothetical question on how a person would respond if their livestock was killed by a predator.

Respondents overall exhibited positive attitudes toward wild predators. Respondents exhibited significantly higher attitude scores indicating a more positive attitude toward snow leopards (Mean = 5.94, Standard Error = 0.26) than wolves (Mean = 5.57, Standard Error = 0.28) [$t_{(114)} = 2.85$, $p = 0.005$]. Overall attitude toward free-ranging dogs was neutral (Mean = −0.31, Standard Error = 0.42). Men exhibited a higher scores toward snow leopards (Mean = 6.73, Standard Error = 0.41) than women (Mean = 5.49, Standard Error = 0.31). With wolves too, men exhibited a higher scores (Mean = 6.63, Standard Error = 0.43) than women (Mean = 4.97, Standard Error = 0.34) (**Figure 3**).

Respondents attributed a reduction in wild prey (29.82%), livestock being easy prey for predators (28.07%), the inability of old animals to hunt wild prey (25.44%) and poor livestock guarding practices (9.65%) as reasons for livestock depredation by wild predators. About 7.02% of the respondents, however, did not attribute any specific reason for livestock depredation.

While respondents overall exhibited positive attitudes toward wild predators, when asked what came to their mind when they thought about these predators, 19.30% expressed dislike for snow leopards, 26.32% for wolves and 73.68% for free-ranging dogs. When asked about where predators should be conserved, 50.00% felt that wild predators should be conserved in national parks alone, 41.67% felt that the conservation of predators should be extended beyond the protected areas to all the regions in which they occur, while 3.51% suggested that they should be conserved and protected inside a zoo. A substantial proportion of respondents said they would chase away a snow leopard (57.02%) or wolf (58.77%) from a livestock kill and use the remains, while 36.84 and 34.21% of the respondents for snow leopards and wolves respectively, remarked that they would let the animal feed undisturbed. None of the respondents expressed a willingness for retaliating or killing the predators.

Similarly, even though there are cultural and religious motivations for conservation of wild predators in the region, 49.00% of the respondents felt that conservation of wild predators was primarily the responsibility of the government, 45.00% felt that it was a responsibility that both people and government should share, while 6.00% felt that it was primarily the responsibility of the villagers.

Factors Influencing the Respondent's Attitudes Toward Predators

The set of models examined, the model weight and AIC_c scores are given in **Appendix I** and the estimates of coefficients using the best fit model is summarized in **Table 3**. In case of snow leopards, the best fit model ($\omega i = 0.38$) explaining the attitudes of people included only gender. Gender alone positively affected attitudes toward snow leopards with gender male increasing it by 1.13 ± 0.51. In the case of wolves, the best fit model ($\omega i = 0.61$) suggested that gender positively affected people's attitude toward wolves with gender male increasing the attitude score by 1.65 ± 0.54. The next best model ($\omega i = 0.27$) containing gender and religion was within 2 Δ AICc of the best model. We used model averaging to estimate the coefficients for these two models, but the effect of religion was not significant No single model emerged as the best fit with free-ranging dogs with eight different models within 2 Δ AICc. We used model averaging to compute the coefficients of parameters using these eight competing models. The model intercept was negative and none of the factors were significant.

DISCUSSION

Persistent human-wildlife conflict, often addressed through lethal control of predators is a compelling reason to establish conservation reserves for predators away from human settlements (Packer et al., 2013). But establishing large conservation reserves is not feasible and existing ones may be insufficient for long term conservation. Most of the protected areas in the snow leopard range are relatively small compared to average home range size of snow leopards (Johansson et al., 2016) and only a small proportion of snow leopard

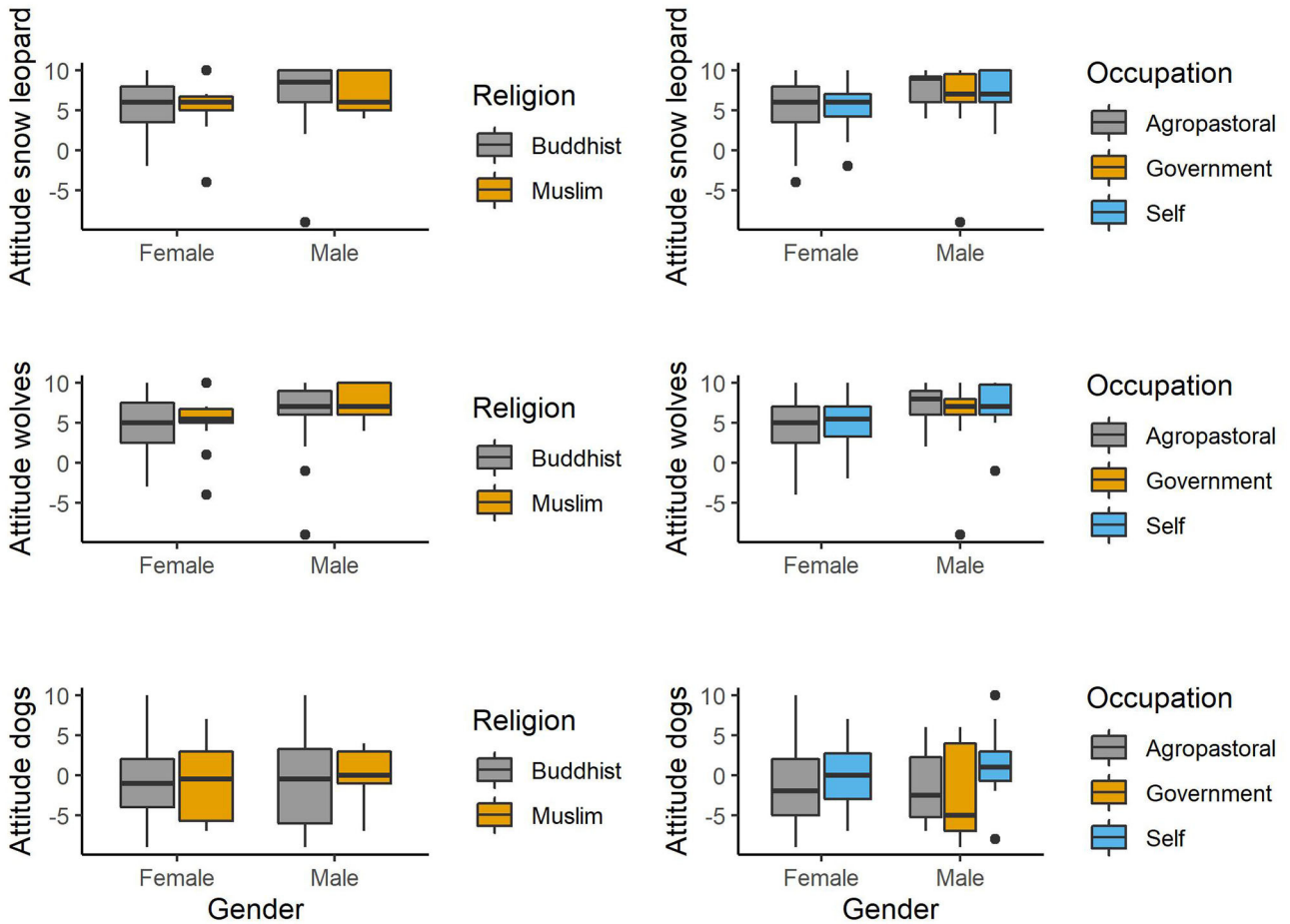

FIGURE 3 | Boxplot showing the relationship between religion and occupation to attitudes of respondents toward snow leopards, wolves, and free ranging dogs. The plot shows minimum, first quartile, median, third quartile, and maximum values of attitudes. Outliers are indicated by dark circles.

TABLE 3 | Summary of estimates of coefficients using the best fit models for determinants of attitudes toward wild carnivores and free ranging dogs.

	Snow leopard		Wolves		Free ranging dogs	
Model parameters	**Estimate**	**Standard error (SE)**	**Estimate**	**Standard error (SE)**	**Estimate**	**Standard error (SE)**
(Intercept)	5.54	0.36	4.93	0.41	−0.33	0.47
Education	–	–	–	–	−0.27	0.47
Age	–	–	–	–	−0.22	0.43
No. of income sources	–	–	–	–	−0.04	0.19
Religion (Muslim)	–	–	0.18	0.51	0.08	0.41
Livestock owned	–	–	–	–	−0.00	0.13
Gender (Male)	**1.13**	**0.51**	**1.64**	**0.54**	−0.02	0.28
Livestock killed	–	–	–	–	−0.00	0.13

The values in bold indicate the factors that emerged as significant determinants of attitudes.

range (14–19%) is formally protected (Deguignet et al., 2014). Besides, there is growing resistance toward the formation of new protected areas because of perceived and real historical and ongoing injustices and curtailment of rights of local communities because of top-down conservation approaches (Guha, 2000). A growing body of work shows that the co-existence of people and predators is possible under certain conditions (Athreya et al., 2013; Odden et al., 2014; Sharma et al., 2015; Majgaonkar et al., 2019) and may even be mutually beneficial for people and predators (Banerjee et al., 2013).

Instead of asking whether sharing or land sparing would be better for carnivore conservation, an appropriate question would be to examine what approach would work best under what set of conditions.

Livestock Mortality: Patterns and Reasons

Livestock mortality caused by wild predators is considered responsible for high economic losses and negative attitudes of affected communities toward them (Bagchi and Mishra, 2006; Chen et al., 2016; Farrington and Tsering, 2019). Our study revealed that weather-related events were the most significant contributors to livestock losses and people exhibited a positive attitude toward wild predators despite livestock depredation at our study site. Our findings highlight the context specific variation that exists in human-wildlife interactions, and we emphasize that generalizations must be avoided in the absence of evidence upon which to do so. Unpredictable and harsh weather events in the Himalaya often cause loss of a large number of livestock. For instance, in the year 2012–2013, a staggering 24,000 heads of livestock were lost because of heavy snowfall in Leh district (Department of Sheep Husbandry, Leh, personal communication). Such events are likely to increase in frequency and severity in future due to climate change impacts. Recent studies on human snow-leopard interactions report similar results where a large proportion of livestock loss was caused by factors such as accidents, disease and cold (Li et al., 2013; Aryal et al., 2014).

Amongst predators, snow leopards, emerged as the primary predators of livestock, also resulting in the highest economic losses. Approximately 60% of livestock depredation by snow leopards occurred inside the corrals, showing that predator-proof corrals could help in mitigating livestock losses caused by snow leopards. Snow leopards occasionally get inside poorly constructed corrals and cause extensive livestock losses (Jackson et al., 2010). An important question that remains unanswered is whether predator proof corrals also result in a shift in people's attitudes toward snow leopards.

Livestock predation by snow leopards was closely followed by predation by free-ranging dogs and wolves. However, the highest depredation of livestock occurred around the village in case of free-ranging dogs and in the pastures away from villages in case of wolves showing why a multi-pronged approach to reduce livestock losses by predators is necessary. Free-ranging dogs are significant predators of small-bodied livestock in the Himalaya to the extent that many communities have stopped rearing small-bodied livestock (Singh et al., 2015). Free-ranging dogs in the Spiti valley in the Trans-Himalaya caused the majority of livestock losses and preferred small-bodied livestock (Home et al., 2017). That livestock may not display anti-predatory behaviors toward free-ranging dogs (Laporte et al., 2010) means that local communities would have to invest far more in protecting livestock from free-ranging dogs. However, further investment in livestock protection reduces the time/resources available to invest in new and emerging opportunities, such as cash crops and tourism.

Livestock mortality was higher during the period of agricultural activities (May to August) as people are pre-occupied and livestock herding becomes lax. In the post-harvest season too, small-bodied livestock is left to graze in the agricultural fields unattended. Overall, poor livestock management which includes a decline in the traditional livestock herding practices, reliance on herders from plains, inadequate focus on livestock health and nutrition and poorly designed corrals that do not protect livestock from predators and chilly weather resulted in high livestock mortality. Conservation programs that aim to reduce livestock mortality therefore can focus on multiple aspects of livestock management instead of focusing solely on protecting livestock from carnivore caused mortality.

Economic Losses Because of Livestock Mortality

More than half of the economic losses owing to livestock mortality occurred because of weather and disease. In comparison, wild predators were responsible for less than one-third of economic losses. Amongst predators, the monetary loss was highest because of snow leopards, followed by free-ranging dogs and wolves. Despite snow leopard causing maximum economic loss among predators, respondents exhibited a higher positive attitude toward snow leopards which is counterintuitive and challenges the assumption that carnivore caused livestock mortality and resultant economic loss is primarily responsible for negative attitudes of people toward predators. The per capita loss because of wild predators was US$153 per year which is substantial (almost 57% of per capita income of the region) given the approximate per capita income of US$270 in the study area. A similar extent of economic loss because of wild predators (USD$190) had been reported earlier from the region (Namgail et al., 2007a). The per capita economic losses because of weather and disease combined amounted to US$218.4 per year, approximately 81% of per capita income. The large proportion of livestock loss because of disease and weather highlights the need for a multi-pronged strategy to reduce livestock losses by including aspects of livestock nutrition and health, animal husbandry and an enhanced ability to predict and respond to extreme weather events besides preventing livestock depredation by predators.

Attitudes of People Toward Predators

The predominant positive attitude of people toward wild predators in this study is counter-intuitive and contrasts with similar studies in the Trans-Himalaya which reported a negative attitude of people toward wild predators (Bagchi and Mishra, 2006; Suryawanshi et al., 2014; Bhatia et al., 2016). Our research reveals that human attitudes toward predators can vary depending upon environmental and social factors and a context specific approach to understand human-wildlife interactions is a must. Livestock depredation was not the key driver of the negative attitudes of people toward predators in our study area and indicates the possibility that people, and predators can potentially share space in multiple use landscapes

under specific contexts. The positive attitude of people toward predators could be because our study site is in the zone of influence of an urban center, livestock holding is relatively low (average 21 livestock heads per household) and people have multiple sources of income. The surveyed villages were at the periphery of Leh town (maximum distance being 40 km) with access to commercial ventures such as tourism, roads, and communications, allowing people to diversify their sources of income and not rely solely on livestock. Respondents had significantly higher attitudes scores toward snow leopards than wolves in the study area, even though snow leopards killed more livestock than wolves and caused higher economic losses. The positive attitude toward wolves in our study area also contrasts with the widespread aversion to wolves around the world (Kansky et al., 2014; Dressel et al., 2015) that probably results from their ecology and behavior and from an inherent cultural bias that denigrates them (Kellert, 1991; Kellert et al., 1996; Kleiven et al., 2004).

While overall, respondents exhibited a positive attitude toward wild predators, men exhibited higher positive attitudes than women. Globally, studies on human-wildlife relationships reveal that women have a higher negative attitude toward wildlife than men (Kleiven et al., 2004; Ogra, 2008) because of a higher perception of risk or fear (Prokop and Fančovičová, 2010), fewer interactions and engagement with conservation agencies compared to men (Gillingham and Lee, 1999) and higher responsibilities toward the household leading to higher resentment toward predators (Ogra, 2008). Political ecologists suggest that gender plays an essential role in shaping people's relationship to their environment (Rocheleau, 2008) and considering gendered differences is essential toward effective conservation communication, especially for designing messages and delivery strategies (Gore and Kahler, 2012). Our results suggest that conservation organizations could specifically focus on inclusion of women in conservation programs.

Buddhist monasteries in the Tibetan plateau play a vital role in the conservation of snow leopards (Li et al., 2013), stewardship of nature and ethical treatment of animals is an essential tenet of Islam in the Western Himalaya (Bhatia et al., 2016) and killing of big cats a taboo in several animistic traditions in South Asia. Many studies propose that religion, mediated by factors such as social norms, fear, perception of risk and socioeconomics, is an important driver of people's attitudes toward predators (Goldman et al., 2010; Galen, 2012). However, our results do not show a noteworthy influence of religion on the attitudes of people toward predators. Differences in religious philosophies, however, could be considered in conservation messaging to stress on environmental stewardship in case of Islam and interdependence of people and wildlife in case of Buddhism (Bhatia et al., 2016).

Tangled Layers of Coexistence

A deeper probe of our results reveals interesting facets of people's relationship with predators. While overall, respondents exhibited positive attitudes toward predators, their relationship with the predators in the landscape seems far more nuanced. For instance, while most respondents expressed a desire to see snow leopards and wolves in their surroundings, they were less willing to see free-ranging dogs in the same environment. Contrary to our expectation that people would display negative attitudes toward free ranging dogs, our results show that people exhibited neutral attitudes toward them. Two third of the respondents were unwilling to share space with dogs and most stated they were afraid to step out especially at dawn and dusk because of fear of dogs, affecting their routine life. Yet local communities in the region invoke compassion and ethics rooted in Buddhism on the question of dog population control (Gagné, 2019).

Similar contradictions emerge for wild predators. For instance, while an overwhelming majority of the respondents expressed support toward protection and conservation of wild predators and agreed that their presence was a sign of a healthy environment, the willingness to share space with them was less discernible as half of the respondents remarked that predators should be conserved only inside formally protected areas such as national parks. These contradictions likely stem from chasm between goals of wildlife conservation and livestock production where government agencies and conservation organizations are seen as custodians of wildlife. Disillusion of local communities with protected areas is reported across South Asia, due to a history of curtailment of community rights to manage their resources, eviction of local communities for the formation of protected areas and poor involvement of local communities in conservation decision making (Agrawal and Gibson, 1999; Rangarajan and Shahabuddin, 2006; Massé, 2016). These contradictions could also be due to "NIMBY" (Not In My Backyard) sentiment (Freudenburg and Pastor, 1992), cognitive dissonance (Festinger, 1957; Morgan, 1992) and even conflicting values and belief systems (Manfredo, 2008). The concept of NIMBY is commonly used to explain public opposition to unwanted developments around their homes and communities, but pejorative use of the concept in certain situations has led to recommendations that it be used cautiously (Burningham, 2000; Devine-Wright, 2009). Cognitive dissonance is the discomfort that arises from conflicting beliefs and influences how people make decisions and evaluate information (Festinger, 1957). In the context of conservation when there is a dissonance between attitudes and behaviors, the attitude is likely to change to accommodate the behavior (Fernández-Llamazares et al., 2020). Similarly while values are theorized to be shared by people within a culture, the people might still differ on application of values in their individuals contexts, based on their beliefs, especially in the case of human-wildlife interactions (Fulton et al., 1996).

CONCLUSION

Conservation literature uses the term "human-snow leopard conflict" to characterize a persistent antagonism of people toward snow leopards over the killing of livestock. Livestock predation by wild predators causes economic losses and resultant reduced social tolerance toward wild predators over persistent livestock loss leads to their retaliatory killings. Our study demonstrates the need for context specific research on human-wildlife conflicts by showing that a substantial proportion of livestock mortality occured because of disease and weather-related events at our study site and local

communities exhibited a positive attitude toward wild predators despite losing livestock to them. A deeper analysis of results revealed a more nuanced and complex relationship with wild predators that includes positive affirmations, contradictions, and ambiguity.

A detailed analysis of relationship between people and snow leopards should be conducted through qualitative social science research (Rust et al., 2017). Specifically in case of snow leopards, the human dimensions research, despite its obvious significance has lagged far behind the ecological research (Sharma and Singh, 2020).

Future studies should examine whether a multi-pronged strategy to reduce livestock losses that includes preventing livestock depredation through predator-proof corrals, incentivising traditional herding practice and livestock disease control with a focus on nutrition and health could be more effective in reducing livestock losses.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

The study was reviewed and approved by Ethics and Social Safeguards Committee at WWF-India. The participants provided their oral informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

RS designed the study and analyzed data. MP carried our fieldwork. RS and MP wrote the article. Both authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcosc.2021.767650/full#supplementary-material

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